

Chapter 5.20

Decision Support System for Greenhouse Tomato Yield Prediction using Artificial Intelligence Techniques

F. Zhang

University of Warwick, UK

D. D. Iliescu

University of Warwick, UK

E. L. Hines

University of Warwick, UK

M. S. Leeson

University of Warwick, UK

S. R. Adams

University of Warwick, UK

ABSTRACT

This chapter introduces a decision support system which is capable of predicting the weekly yields of tomatoes in a greenhouse. The development of this system involves a set of Artificial Intelligence based techniques, namely Artificial Neural Networks (ANNs), Genetic Algorithms (GAs), and

Grey System Theory (GST). The prediction was performed by an ANN using a set of optimised input variables, chosen from all available environmental and measured yield parameters. The reduction and optimisation of the inputs was done using either GAs or GST and compared in terms of the ANN's performance. It was shown that the use of artificial intelligence based methods can offer a promising approach to yield prediction and compared favourably with traditional methods.

DOI: 10.4018/978-1-60960-818-7.ch5.20

INTRODUCTION

Both supermarkets and tomato growers require reliable supplies of high quality fruit in agreed quantities. Growers have increased fruit quality and yields in many parts of the world through the use of greenhouses where the growing/environmental conditions can be controlled and by selecting better cultivars. However, weekly yields can fluctuate and this can pose problems of both over-demand and over-production if the yield cannot be predicted accurately. In this respect growers and scientists are looking for ways to forecast tomato yield in order to plan greenhouse operations and marketing and thus reduce costs and increase profits. A large number of prediction models and prototypes have been developed in the past few decades, based on specialist knowledge of tomato physiology and growing conditions. However, they tend to deal accurately with total yields, but poorly with weekly yield fluctuations.

This chapter introduces a greenhouse tomato weekly yield prediction system which was developed using a combination of Artificial Intelligence (AI) based techniques which process environmental data, without relying on complex plant physiology. The techniques used are Genetic Algorithms (GAs), Grey System Theory (GST) and Artificial Neural Networks (ANNs). The ANNs were designed to perform the prediction function using a set of optimised input variables. The GA and GST were used in the selection and optimisation of input variables from all the available measurements, such as temperature, radiation, CO₂ concentration, vapour pressure deficit and previous yield.

BACKGROUND

As mentioned above, tomato growers are sometimes contracted to sell agreed quantities of produce to supermarkets. However, tomato yields often vary from week to week, and so the ability

to accurately predict future yields would give them a competitive advantage. If a grower is forecast to have insufficient fruits in a given week they could source additional produce from elsewhere, and if they are predicted to have excess fruits they could look for alternative markets or arrange promotions. As a result there has been considerable interest from growers and researchers for developing tomato yield prediction systems. (S.R. Adams, Cockshull, & Cave, 2001; S.R. Adams, Valdes, Cave, & Fenlon, 2001)

The systems developed take into account various growing conditions and factors affecting plant development. Environmental conditions that influence the growth and productivity of tomato plants include air temperature (day and night), fruit temperature, radiation, CO₂ concentration, fruit load, plant density, stress etc. The fluctuation of temperature affects mostly the time of fruit ripening and rate of fruit growth. The research work of Willits and Peet (1998) also suggests that warmer conditions in the greenhouse at night can significantly improve the quality and quantity of tomatoes. The relationship between temperature and yield is complex and studies have shown that the sensitivity of fruits to temperature changes over time, as fruits become more sensitive to temperature as they approach maturity. This explains why raising the greenhouse temperature results in a peak in yield followed a few days later by a yield reduction (Adams & Valdes, 2002; Mulholland, Edmondson, Fussell, Basham & Ho, 2003). However, temperature fluctuations do not significantly influence the overall tomato yields when compared with temperature controlled growing conditions (Koning, 1988, 1990) however they influence the weekly tomato yields in greenhouses. Studies funded by the UK governmental agency DEFRA looked at understanding how the aerial environment affected the pattern of tomato yields. They showed that the primary cause of fluctuations in yield was due to the effect of temperature on fruit ripening and that the variation in ripening time smoothes out the effect on the yield that the

15 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/decision-support-system-greenhouse-tomato/56210

Related Content

An Improved Particle Swarm Optimization Algorithm Based on Quotient Space Theory

Yuhong Chi, Fuchun Sun, Weijun Wang and Chunming Yu (2012). *International Journal of Software Science and Computational Intelligence* (pp. 1-13).

www.irma-international.org/article/improved-particle-swarm-optimization-algorithm/72877

Petri Nets and Discrete Events Systems

Juan L. G. Guirao and Fernando L. Pelayo (2011). *International Journal of Software Science and Computational Intelligence* (pp. 13-22).

www.irma-international.org/article/petri-nets-discrete-events-systems/60746

Evaluation of NoSQL Databases: MongoDB, Cassandra, HBase, Redis, Couchbase, OrientDB

Houcine Matallah, Ghalem Belalemand Karim Bouamrane (2020). *International Journal of Software Science and Computational Intelligence* (pp. 71-91).

www.irma-international.org/article/evaluation-of-nosql-databases/262589

A Formal Knowledge Representation System (FKRS) for the Intelligent Knowledge Base of a Cognitive Learning Engine

Yousheng Tian, Yingxu Wang, Marina L. Gavrilova and Guenther Ruhe (2013). *Advances in Abstract Intelligence and Soft Computing* (pp. 1-15).

www.irma-international.org/chapter/formal-knowledge-representation-system-fkrs/72769

Salp: Metaheuristic-Based Clustering for Wireless Sensor Networks

Vrajesh Kumar Chawra and Govind P. Gupta (2020). *Nature-Inspired Computing Applications in Advanced Communication Networks* (pp. 41-56).

www.irma-international.org/chapter/salp/240952